National Aeronautics and Space Administration

NASA Small Spacecraft Technology Program & Small Spacecraft Systems Virtual Institute

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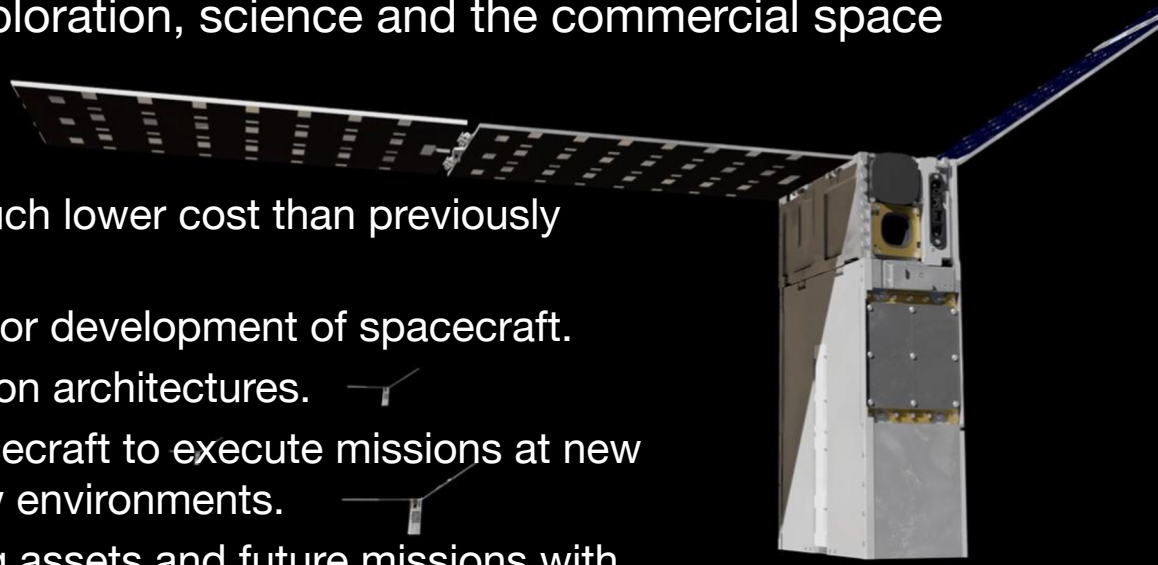
2024 AIAA SciTech Forum

Small Spacecraft Technology Program Objectives

The Small Spacecraft Technology program expands U.S. capability to execute unique missions through rapid development and demonstration of capabilities for small spacecraft applicable to exploration, science and the commercial space sector.

- Enable execution of missions at much lower cost than previously possible.
- Substantially reduce time required for development of spacecraft.
- Enable and demonstrate new mission architectures.
- Expand the capability of small spacecraft to execute missions at new destinations and in challenging new environments.
- Enable the augmentation of existing assets and future missions with supporting small spacecraft.



Starling Spacecraft
Image Credit: NASA

Small Spacecraft Technology Program

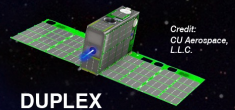
SPACE TECHNOLOGY MISSION DIRECTORATE

Expanding NASA's ability to execute unique missions through rapid development and demonstration of capabilities for small spacecraft applicable to exploration,science and the commercial space sector.

Starling
Technologies for Distributed Small Spacecraft Missions

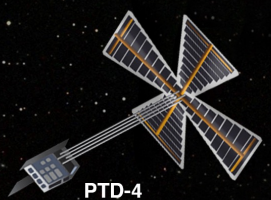
PTD-3
Pathfinder Technology Demonstrator-3 TeraByte InfraRed Delivery (TBIRD)

PTD-R
Pathfinder Technology Demonstrator-R Monolithic UV/SWIR/VIS Camera



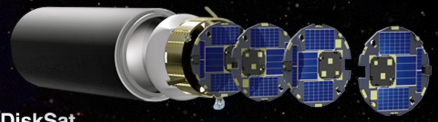
Credit: CU Aerospace, L.L.C.

DUPLEX
Dual Propulsion Experiment (DUPLEX) CubeSat



PTD-4
Pathfinder Technology Demonstrator-4 Lightweight Integrated Solar Array and anTenna (LISA-T)

CAPSTONE
Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment



DiskSat
Two-Dimensional, High-Power, High-Aperture, Maneuverable Spacecraft

Credit: ExoTerra Resource, LLC.

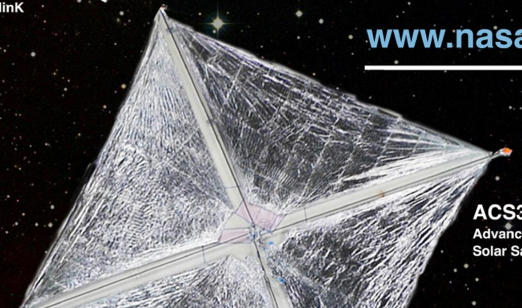
Courier
Solar Electric Propulsion Module

GPDM
Green Propulsion Dual Mode

CLICK
CubeSat Laser Infrared CrosslinK

R5
Rapid Technology Maturation

PY4
Four-CubeSat Swarm of PyCubed-Based Spacecraft

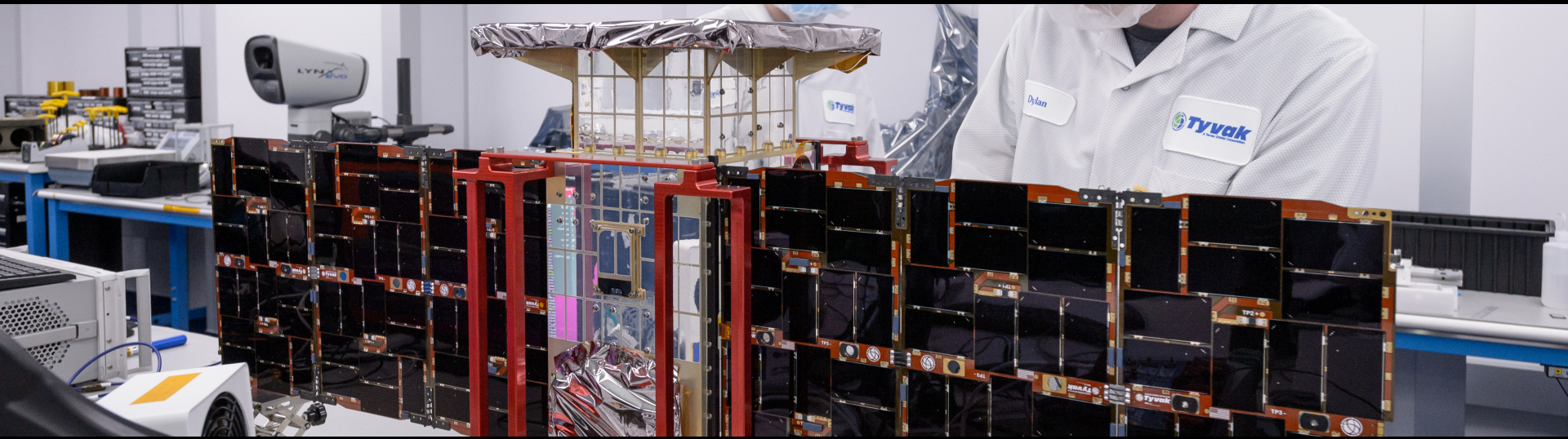


ACS3
Advanced Composite Solar Sail System

www.nasa.gov/smallspacecraft

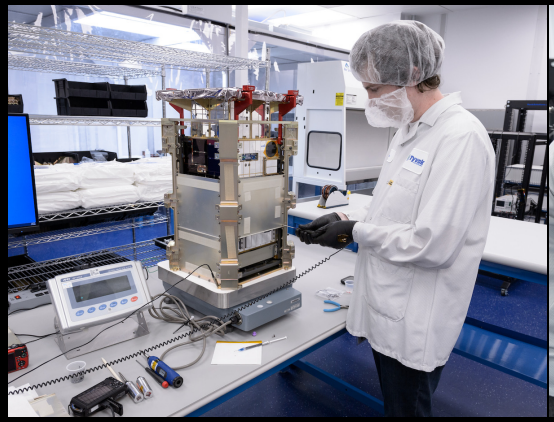
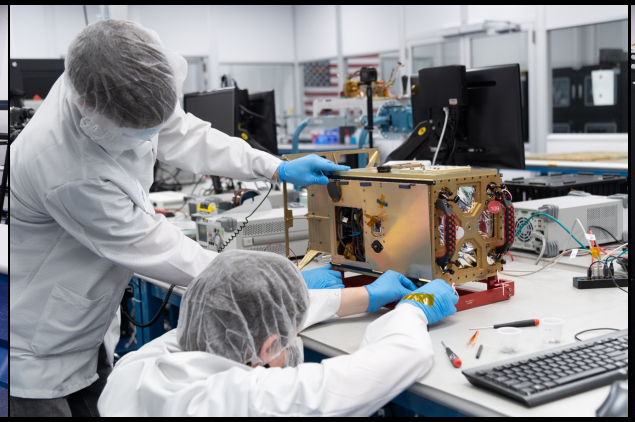
www.nasa.gov

CAPSTONE - Launched June 28, 2022 – Currently in Lunar Orbit



Demonstrated ability to enter and maintain a near rectilinear halo orbit around the Moon. Demonstrated one & two way ranging and autonomous spacecraft navigation.

CAPSTONE Industry and Academic Partners

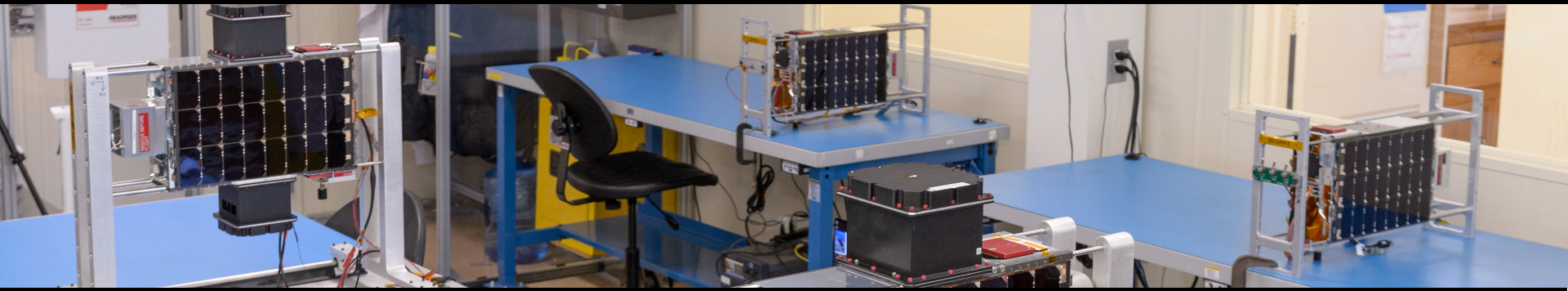




CAPSTONE represents an innovative collaboration between NASA and its partners to provide rapid results and feedback to inform future exploration and science missions.

- Advanced Space of Westminster, Colorado, developed and is operating CAPSTONE.
- Terran Orbital Corporation, of Irvine, California, designed and built the CubeSat platform.
- Stellar Exploration, Inc. of San Luis Obispo, California, provided the propulsion system.
- Rocket Lab of Long Beach, California, provided the launch service.

The mission is also supported by the Space Dynamics Laboratory, Orion Space Solutions, Tethers Unlimited, Inc., and Morehead State University.

Starling 1.0 – Launched July 17, 2023 – Engaged in On-Orbit Operations



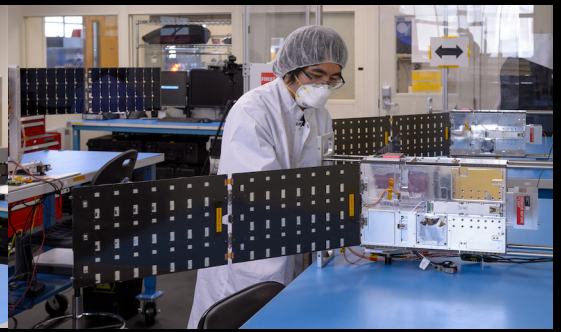
Starling's mission includes four main demonstrations: swarm maneuver planning and execution, communications networking, relative navigation, and autonomous coordination between spacecraft.

These Four Technologies Include:

- Cluster flight control algorithms: *(ROMEO – Onboard Cluster Flight Control)*
- Network communication protocols: *(MANET – Crosslink/Networking)*
- Relative navigation algorithms: *(StarFOX –Relative Navigation)*
- Autonomous reactive operations software: *(DSA – Distributed Spacecraft Autonomy)*

NASA Starling 1.0/*1.5 Industry & Academic Partners





NASA partners with the following industry and academic entities for these demonstrations.

- Blue Canyon Technologies of Boulder, Colorado, designed and manufactured the spacecraft buses and is providing mission operations support.
- Rocket Lab USA, Inc., provided launch and integration services

Partners supporting Starling's payload experiments include:

- Stanford University's Space Rendezvous Lab in Stanford, California
- Emergent Space Technologies of Laurel, Maryland, CesiumAstro of Austin, Texas
- L3Harris Technologies, Inc., of Melbourne, Florida
- NASA Ames – with funding support by NASA's Game Changing Development program within STMD

*The Starling 1.5 extended mission is developing technology and operational protocols for autonomous maneuvering coordination between spacecraft constellations to enable nascent space traffic management capabilities. Among other partners, SpaceX is an industry partner for this demonstration.

University SmallSat Technology Partnership Successes to Date

Investments:

- Over $30,000,000 awarded
- 54 partnerships in 6 cohort years
- 36 universities in 22 states (+6 supporting collaborators in 6 states)
- 8 of 10 NASA centers partnered

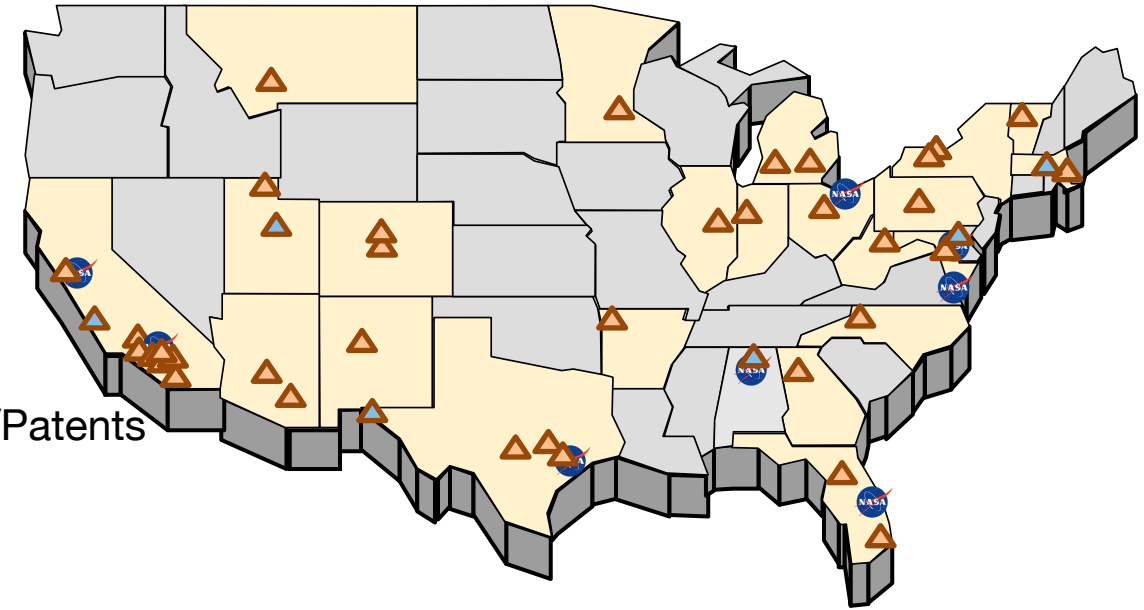
Results:

- 24 flight demonstrations performed/planned
- 1 Intersatellite Network Planning/ Routing tool software open-sourced
- Numerous New Technology Reports/Patents
- 30+ conference presentations
- 50+ papers published
- 100+ students involved
- Many technology readiness levels (TRL) raised

36 Universities in 22 States

8 NASA Centers (including JPL FFRDC)

6 Supporting University Collaborators in 6 States



National Aeronautics and Space Administration

Small Spacecraft Systems Virtual Institute (S3VI)

Promoting Innovative Concepts

Building Community through:

Sharing Knowledge
- SmallSat LEARN Forum
- Community of Practice Mission Accomplished Webinar Series
- Access to Space Announcements
- S3VI Quarterly Newsletter
- CubeSat 201

Building Tools
- Small Spacecraft Reliability Initiative Knowledge Base Tool
- Small Spacecraft Information Search
- State of the Art Report
- Space Mission Design Tools Collection
- Anomaly Alert Reporting System

Connecting People and Ideas
- Industry Days Webinar Series
- SmallSat Technology Partnerships – TechExpo
- Cross-Agency Collaboration

Identifying Emerging Technology Opportunities

www.nasa.gov/smallsat-institute

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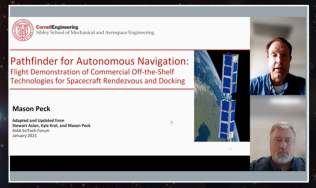
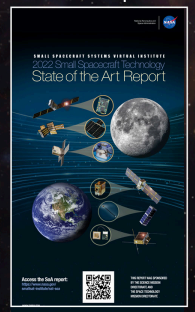
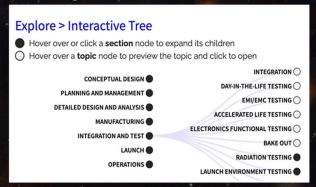
Community of Practice Webinar Series



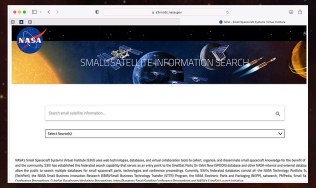
Small Spacecraft Technology State of the Art Report



Small Spacecraft Reliability Initiative Knowledge Base



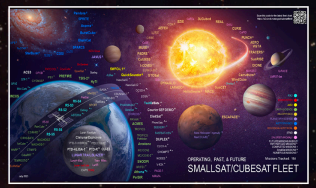
Small Spacecraft Information Search



S3VI Web Portal

S3VI Newsletter

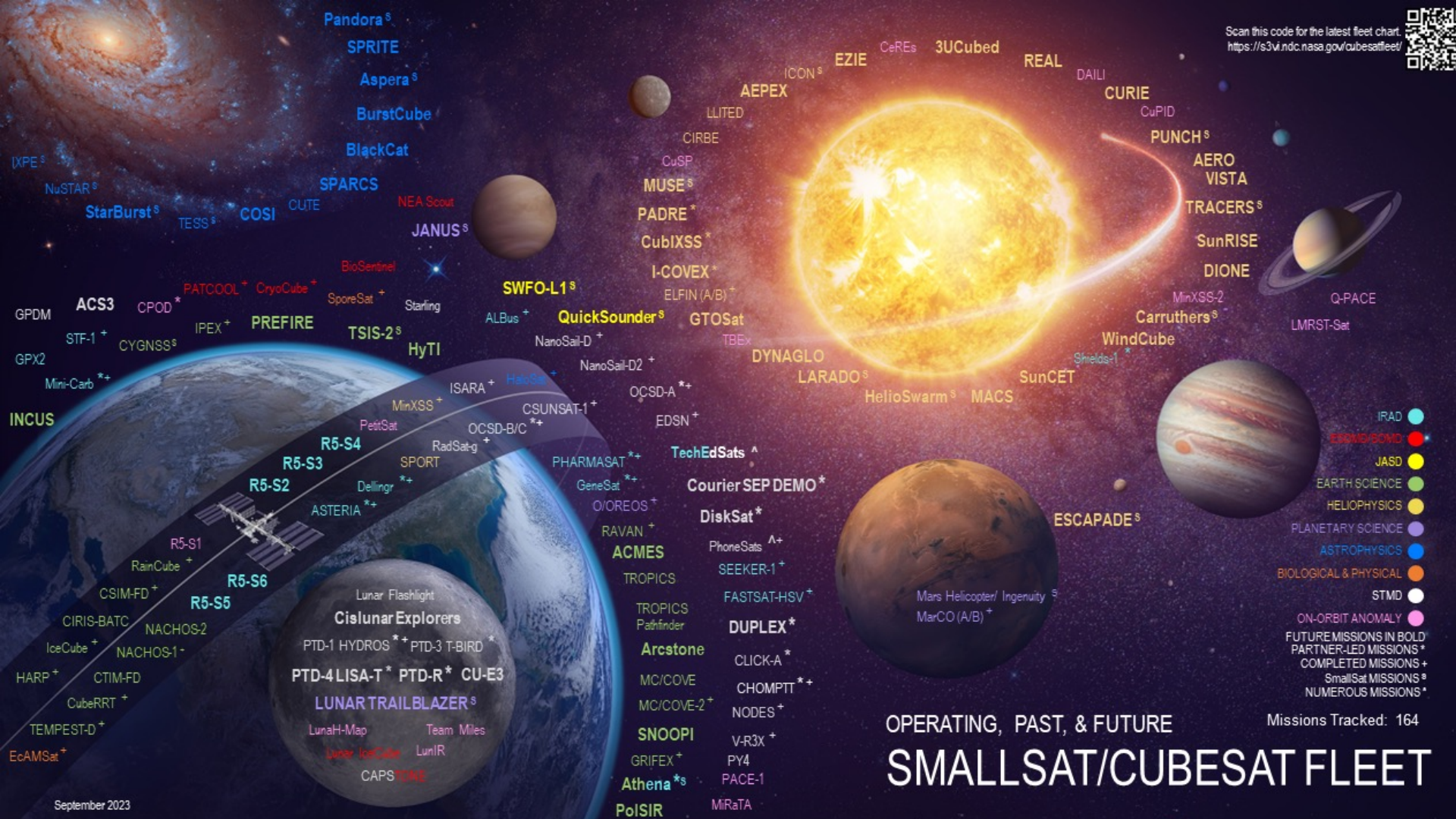
SmallSat / CubeSat Fleet Chart



NASA SmallSat LEARN Forum

LaunchPortal: Potential Rideshare Opportunities

Mission Name	Launch Date (NET)	Primary Orbit	Apogee (km)	Perigee (km)	Inclination (deg)	Insertion	Rideshare Adapter
JPSS-2	11/1/22	SSO, Polar	810	810		1325 LTAN	None: ULA C-Adapters surrounding LOFTID secondary payload. (no Rideshare opportunities available)
IMAP	2/1/25	L1			28	C3 max += -0.5	ESPA Grande (no Rideshare opportunities available)
SPHEREX	2/28/25	SSO	650	650		6am MLTAN	Full SPA (no additional RS opportunities available)
JPSS-3	2025-2027	SSO				13:30 MLTAN	TBD
COSI	2025/09	LEO	550	550	5		TBD
SENTINEL 6B	2025/11	LEO	1336	1336	66	TBD	TBD
NEO SURVEYOR	2026/05	L1				C3 (lbd)	TBD
MUSE	2027/04	SSO	620	620	97.9	6am MLTAN	TBD
VERITAS	2028-2030	Venus				C3=17	TBD


Scan this code for the latest fleet chart.
https://s3vi.ndc.nasa.gov/cubesatfleet/
Pandora S
SPRITE
Aspera S
BurstCube
BlackCat
IXPE S
NuSTAR S
SPARCS
StarBurst S
TESS S
COSI
CUTE
NEA Scout
JANUS S
BioSentinel
PATCOOL +
CryoCube +
SporeSat +
Starling
GPDM
ACS3
CPOD *
IPEX +
PREFIRE
TSIS-2 S
HyTI
STF-1 +
CYGNSS S
GPX2
Mini-Carb *+
INCUS
ISARA +
HaloSat +
MinXSS +
CSUNSAT-1 +
PetitSat
OCSD-B/C *+
R5-S4
R5-S3
R5-S2
RadSat-g +
SPORT
Dellingr *+
ASTERIA *+
R5-S1
RainCube +
R5-S6
R5-S5
CSIM-FD +
CIRIS-BATC
NACHOS-2
IceCube +
NACHOS-1 -
HARP +
CTIM-FD
CubeRRT +
TEMPEST-D +
EcAMSat +
Lunar Flashlight
Cislunar Explorers
PTD-1 HYDROS *+ PTD-3 T-BIRD *
PTD-4 LISA-T * PTD-R * CU-E3
LUNAR TRAILBLAZER S
LunaH-Map
Team Miles
Lunar IceCube
LunIR
CAPSTONE
September 2023
SWFO-L1 S
ALBus +
QuickSounder S
NanoSail-D +
NanoSail-D2 +
OCSD-A *+
EDSN +
PHARMASAT *+
GeneSat *+
O/OREOS +
RAVAN +
ACMES
TROPICS
TROPICS Pathfinder
Arcstone
MC/COVE
MC/COVE-2 +
SNOOPI
GRIFEX +
Athena *S
PoISIR
TechEdSats ^
Courier SEP DEMO *
DiskSat *
PhoneSats ^+
SEEKER-1 +
FASTSAT-HSV +
DUPLEX *
CLICK-A *
CHOMPTT *+
NODES +
V-R3X +
PY4
PACE-1
MiRaTA
ICON S
EZIE
CeREs
3UCubed
REAL
DAILI
AEPEX
LLITED
CIRBE
CuSP
MUSE S
PADRE *
CubIXSS *
I-COVEX *
ELFIN (A/B) +
GTOSat
TBEx
DYNAGLO
LARADO S
HelioSwarm S
MACS
SunCET
CURIE
CuPID
PUNCH S
AERO
VISTA
TRACERS S
SunRISE
DIONE
MinXSS-2
Carruthers S
WindCube
Shields-1 *
Q-PACE
LMRST-Sat
ESCAPADE S
Mars Helicopter/ Ingenuity S
MarCO (A/B) +
IRAD
ESSMD/SOMD
JASD
EARTH SCIENCE
HELIOPHYSICS
PLANETARY SCIENCE
ASTROPHYSICS
BIOLOGICAL & PHYSICAL
STMD
ON-ORBIT ANOMALY
FUTURE MISSIONS IN BOLD
PARTNER-LED MISSIONS *
COMPLETED MISSIONS +
SmallSat MISSIONS S
NUMEROUS MISSIONS ^
OPERATING, PAST, & FUTURE
SMALLSAT/CUBESAT FLEET
Missions Tracked: 164

S3VI Resources Available to All

The S3VI provides the US SmallSat research community with access to mission enabling information and maintains engagement with small spacecraft stakeholders in industry, government and academia. The S3VI resources listed below are available to all at: https://www.nasa.gov/smallsat-institute/

Contact us at: agency-smallsat-institute@mail.nasa.gov

- Community of Practice Webinar Series
- Small Spacecraft Reliability Initiative Knowledge Base Tool
- LaunchPortal
- Small Spacecraft Guidebooks
- United Nations Office of Outer Space (UNOOSA) Systems Engineering Webinar Series
- NASA Small Spacecraft State of the Art Report
- S3VI WebPortal
- Quarterly S3VI Newsletter
- Small Spacecraft Information Search
- Space Mission Design Tool Catalog

S3VI is sponsored by NASA's Space Technology Mission Directorate


NASA